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Relationship between type 2 diabetes and oral health status

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ABSTRACT

Aims: This prospective cross-sectional study aimed to compare the decayed, missing, filled teeth (DMFT) index values and dental caries prevalence of patients with type 2 diabetes mellitus (T2DM) to those of healthy individuals, and to examine the effect of inadequate glycemic control on DMFT and caries prevalence.

Methods: T2DM patients were divided into two groups based on metabolic control: well-controlled (WC; HbA1c ≤7%) and poorly controlled (PC; HbA1c >7%). The clinical parameters assessed were the number of natural teeth, the coronal DMFT index, the simplified oral hygiene index (OHI-S), and body-mass index (BMI).

Results: The DMFT index and number of filled teeth were similar between the WC and healthy control groups. In contrast, the PC group showed significantly higher values than both the WC and control groups. The highest DMFT index (14.38) was observed in the PC group, and the lowest (9.90) in the control group ($p<0.001$).

Conclusion: Patients with poor glycemic control exhibited higher DMFT and filled-teeth (FT) index values than those with good glycemic control. No difference was determined in the decay index between diabetic patients with good or poor glycemic control, and the healthy subjects.

Keywords: DMFT, decay, filling, HbA1c, diabetes

INTRODUCTION

Diabetes is a chronic metabolic disorder characterised by hyperglycemia due to relatively insufficient insulin because of pancreas beta cells dysfunction and insulin resistance in target organs.[1] Chronic metabolic diseases have many systemic symptoms in different organs such as the eyes, kidneys, nerve, heart and vascular systems and have been associated with oral health complications.[2]

Oral findings such as periodontal diseases, tooth loss, saliva dysfunction, taste disorder, xerostomia, candida infection, neurosensorial disorder, and dental decay are seen in patients with diabetes mellitus (DM).[2,3] Of these complications, periodontal diseases such as gingivitis and periodontitis have been the subject of many research studies. At the start of the 1990s, periodontal diseases were named as the "sixth complication" of DM.[4]

Dental caries (DC) are one of the most common chronic oral dseases worldwide. DC can be experienced throughout the lifetime of an individual and most tooth losses are the result of DC.[5]

Although both diseases are linked to carbohydrate intake, there has been little research on the subject of the association between glycemic control and dental decay.[6] Some studies have suggested that there is no clear association between type 2 diabetes (T2DM) and the prevalence of dental decay.[7,8] However, Lin et al.[9] reported that although diabetes and poor glycemic control may not show a significant relationship with DC incidence in adults wih T2DM, these patients have a greater tendency to the formation of more decay lesions. Some studies have shown higher rates of root decay in individuals with T2DM.[10,11]

There have been insufficient studies to determine the relationship between dental decay and glycemic control in patients with DM. Moreover, most of the previous research has deal with the relationship between dental decay and glycemic control in patients with type 1 DM.[12-14]

Glycemic control in non-pregnant adults is defined by the American Diabetes Association (ADA) as well control: hemoglobin A1c (HbA1c)≤7%, and poor control: HbA1c>7%.[15]

Although there are studies in the literature examining DC in adults with T2DM, there are few studies explaining the DMFT index by classifying the HbA1c level. The aim of this study was to compare the DMFT index and oral hygiene status of patients with type 2 diabetes and a healthy control group divided into 2 groups according to the HbA1c level.

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H_0: According to HbA1c, there is no significant difference between the "well controlled-WC" (HbA1c≤7%) and "poorly controlled-PC" (HbA1c>7%) type 2 diabetic groups and the healthy control group in terms of DMFT index, oral hygiene status parameter values.

METHODS

This study was reviewed and approved by the Clinical Researches Ethics Committee of Afyonkarahisar Health Sciences University (Date: 07.07.2023, Decision No. 2011-KAEK-2). All study procedures were in accordance with the principles of the Declaration of Helsinki. All participants gave written informed consent for participation in the study.

This prospective, cross-sectional study was conducted on randomly selected patients among those who applied to the Endocrine Polyclinic of Afyonkarahisar Health Sciences University Hospital. An a priori power analysis for a one-way ANOVA was conducted using G*power 3.1.9.4. Significance level (α): 0.05 (type I error), desired power (1–β): 0.80, Effect size (medium–large range(0.25–0.40),): Cohen's f=0.26. Based on these parameters, the analysis indicated a required total sample size of 147, corresponding to 49 participants per group. Consequently, our study was designed with approximately 50 patients in each group.

The study sample consisted of 100 adults diagnosed with type 2 diabetes mellitus (T2DM) between the ages of 30-60 and 50 healthy individuals as the control group.

The inclusion criteria for the patient group were defined as a diagnosis of T2DM made by an endocrinologist at least 1 year ago according to the ADA/EASD criteria,[16] the presence of at least 15 natural teeth, and age >30 years.

Exclusion criteria for the study were defined as a diagnosis of T1DM, the presence of a serious comorbidity requiring hospitalization such as myocardial infarction, stroke, severe renal dysfunction, or retinopathy, the presence of dementia or mental health illness, pregnancy or breastfeeding, or patients with difficulties in participation.

T2DM patients were divided into two groups according to metabolic control: well controlled (WC): HbA1c≤7% and poorly controlled (PC): HbA1c>7%. These values were used according to the American Diabetes Association Standards of Medical Care in Diabetes.[17]

All study participants underwent a comprehensive evaluation including medical examination and oral health assessment. Each participant was first evaluated by an endocrinologist and their medical history, physical examination findings, fasting blood sugar value and glycated hemoglobin value (HbA1c) were recorded.

In accordance with the study's prospective cross-sectional design, only patients' baseline data were collected. One week after the medical examination, each participant underwent a face-to-face interview at the Faculty of Dentistry, Afyonkarahisar Health Sciences University, during which their sociodemographic characteristics (age, gender, educational status) were recorded.

The dentist performing the oral examination was blinded to the groups (WC, PC, control) and to the clinical and laboratory data of the study participants. The status of the teeth and fillings was recorded during the oral examination. DC were examined visually and on radiographs. The number of decayed teeth (DT), missing teeth (MT), and filled teeth (FT) was recorded, and the DMFT index was calculated as the sum of DT+MT+FT. Teeth with both fillings and crowns were considered FT, and third molars were not included.[18]

For the quantitative evaluation of the oral hygiene status of the patients, the oral hygiene index- simple (OHI-S) was used. This index is a scoring method that is considered the sum of the plaque index (PI) and the calculus index (DI). Six teeth numbered 16, 26, 11, 31, 36, and 46, considered representative of all anterior and posterior teeth, were evaluated. The buccal surfaces of teeth 16-26-11-31 and the lingual surfaces of teeth 36-46 were assessed using a 0-3 rating scale. The oral hygiene status of the patients was recorded according to these points as 0-2 points: good, 2.1-4 points: moderate, 4.1-6 points: poor.[19]

In this study, conducted between September 2023 and March 2024, a comprehensive evaluation of patients was performed, including a full oral health examination and screening for factors associated with DM.

Statistical Analysis

In the statistical analyses of the study data, descriptive statistics were stated as mean±standard deviation values for continuous variables and as number (n) and percentage (%) for categorical variables. The Pearson Chi-square test was applied in the comparisons of demographic data. The cutoff value of 20 remaining teeth was determined for the comparisons of "high" and "low" groups using the Independent Samples t-test. In the comparisons of 3 groups of continuous data, One-Way Variance of analysis was applied and Tukey HSD was used in subgroup comparisons.

RESULTS

Demographic Characteristics

A total of 150 cases, 50 in each group, 17 male and 133 female cases with an average age of 46.61 years, average weight of 76.85 kg, average height of 158.13 cm and average BMI of 30.80 kg/m^2 were evaluated. The mean and standard deviation values of hypertension and coronary artery disease for each group are shown in **Table 1**.

Oral Health Status

It was determined that the mean OHI-S and mean caries index values were similar in all groups. The DMFT index value and the number of FT were similar in the WC group and the healthy control group, and a significant difference was determined in the PC group compared to the other groups. The highest DMFT index value was determined as 14.38 in the PC group, and the lowest value was determined as 9.90 in the control group ($p<0.001$) (**Table 2**).

The number of natural teeth in the PC group was significantly lower than both the WC group and the healthy control group ($p<0.001$) (**Table 2**).

Table 1. Comparison of demographic data between groups

		Control group (HbA1c<5.7%)		Well-controlled DM 5.7≤HbA1c≤7%)		Poorly-controlled DM HbA1c>7%)		Total			
		Mean±SD		Mean±SD		Mean±SD		Mean±SD		p value	
Age		45.76±7.33		47.50±5.12		46.56±7.96		46.61±6.90		0.454	A
Weight		75.38±9.38		78.44±9.43		76.72±9.86		76.85±9.58		0.279	A
Height		158.48±6.72		158.52±6.63		157.38±6.74		158.13±6.67		0.628	A
BMI		30.09±3.95		31.25±3.65		31.06±4.22		30.80±3.95		0.289	A
		n	%	n	%	n	%	n	%		
Gender	Female	45	90.0%	45	90.0%	43	86.0%	133	88.7%	0.767	X
	Male	5	10.0%	5	10.0%	7	14.0%	17	11.3%		
Profession	Farmer	7	14.0%	8	16.0%	10	20.0%	25	16.7%	0.992	X
	Retired	3	6.0%	3	6.0%	4	8.0%	10	6.7%		
	Housewife	23	46.0%	23	46.0%	23	46.0%	69	46.0%		
	Livestock	5	10.0%	6	12.0%	5	10.0%	16	10.7%		
	Officer	6	12.0%	5	10.0%	2	4.0%	13	8.7%		
	Teacher	4	8.0%	3	6.0%	3	6.0%	10	6.7%		
	Textile manufacturer	2	4.0%	2	4.0%	3	6.0%	7	4.7%		
Hypertension	No	45	90.0%	43	86.0%	41	82.0%	129	86.0%	0.515	X
	Yes	5	10.0%	7	14.0%	9	18.0%	21	14.0%		
Coronary artery disease	No	48	96.0%	45	90.0%	44	88.0%	137	91.3%	0.335	X
	Yes	2	4.0%	5	10.0%	6	12.0%	13	8.7%		

A: One-way analyse of variance (Anova) X: Pearson Chi-square, HbA1c: Hemoglobin A1c, DM: Diabetes mellitus, SD: Standard deviation, BMI: Body-mass index

Table 2. Comparison OHI-S, decay, missing teeth, filling, remaining teeth and DMFT index between groups

			Mean±SD	95% CI lower-upper		F	p value	
OHI-S	Control group		1.68±0.81	1.45	1.91	0.040	0.960	A
	Well-controlled DM		1.64±0.82	1.41	1.87			
	Poorly-controlled DM		1.68±0.71	1.48	1.88			
Decay teeth	Control group		3.16±2.53	2.44	3.88	0.383	0.683	A
	Well-controlled DM		2.80±2.28	2.15	3.45			
	Poorly-controlled DM		2.84±1.91	2.30	3.38			
Missing teeth	Control group	a	3.42±2.85	2.61	4.23	7.174	0.001	A
	Well-controlled DM	ab	4.46±3.03	3.60	5.32			
	Poorly controlled DM	b	5.80±3.53	4.80	6.80			
Fiiling teeth	Control group	a	3.32±3.66	2.28	4.36	5.970	0.003	A
	Well-controlled DM	a	3.54±4.09	2.38	4.70			
	Poorly-controlled DM	b	5.74±3.86	4.64	6.84			
Number of remaining teeth	Control group	a	24.58±2.85	23.77	25.39	7.174	0.001	A
	Well-controlled DM	ab	23.54±3.03	22.68	24.40			
	Poorly-controlled DM	b	22.20±3.53	21.20	23.20			
DMFT index	Control group	a	9.90±5.72	8.28	11.52	8.682	<0.001	A
	Well-controlled DM	a	10.80±5.53	9.23	12.37			
	Poorly-controlled DM	b	14.38±5.82	12.73	16.03			

A: One-way analyse of variance (Anova), OHI-S: Oral hygiene index, DMFT: Decayed, missing, filled teeth, SD: Standard deviation, CI: Confidence interval, DM: Diabetes mellitus

The mean values of the DMFT index, FT, MT, remaining teeth and the OHI-S index are presented in Table 2.

DISCUSSION

The main objective of this study was to compare the DMFT index values of T2DM patients with good and poor glycemic control with healthy controls. The study results showed that the DMFT and FT index values of T2DM patients with poor glycemic control were significantly higher than those of patients with poor glycemic control. The DMFT values and the number of MT due to caries were significantly higher in the PC diabetes group than in the healthy control group. These

findings were similar to the results of a study by Bakhshandeh et al.,[10] who associated higher HbA1c levels with higher DMFT values. Another study on diabetic patients by Miko et al.[20] reported that poor glycemic control increased the DMFT index, the number of DCs was lower, and the number of FT was significantly higher. Similar to the present study, Rahiotis et al.[21] found a positive association between DMFT values and serum HbA1c levels. These findings are similar to the findings in the current study, which showed that DMFT index values and FT index values were significantly higher in the group with poor glycemic control.[20] "In individuals with poor glycemic control, persistent hyperglycemia promotes demineralization, biofilm instability, and ultimately lesion formation, creating a cariogenic oral environment that increases the need for restorations and elevates the FT component. Taken together, our findings likely reflect a cumulative history of caries requiring treatment rather than an increased number of restorations.

Previous studies in the literature have shown that patients with diabetes have higher DMFT values and more MT due to caries than patients without diabetes.[8,22-25] Sing et al.[23] examined the salivary components of diabetic patients and showed that the saliva content is prone to tooth decay. Kanjirarh et al.[24] compared diabetic and non-diabetic patients and showed that diabetic patients had more caries and MT due to caries. Reddy et al.[22] also reported more DC in diabetic patients. These results support the results of the present study. In contrast, Gupta et al.[27] reported lower DMFT index values in diabetic patients than in the control group. Aziz et al.[26] did not show any significant difference in DMFT values between the diabetic and control groups, but stated that tooth decay increased with the increase in blood sugar levels. The present study results showed similar carious tooth index values in both T2DM patients with good and poor glycemic control and in the healthy control group. These results were supported by the results of a previous meta-analysis.[28]

Diabetes has been associated with salivary gland dysfunction and increased glucose concentrations in blood and saliva, which promote the growth of oral bacteria and increase the risk of developing DC.[29-31] Despite this possible biological explanation, the duration of diabetes may also be a contributing factor. The current study sample was relatively younger with a shorter duration of diabetes than reported in other studies.[32] Just as there may be a bidirectional relationship between periodontitis and diabetes, this also suggests the possibility of a bidirectional relationship between DC and diabetes.

The relationship between DC and DM is a matter of debate.[7,29] Therefore, the lack of significant differences observed in the caries index between well-controlled, poorly controlled, and non-diabetic groups may be due to the reasons mentioned above.[11,30] The results of the present study showed no difference in caries incidence between diabetic patients and healthy controls, consistent with the findings of other studies.[7,33] As reported in the literature, this situation was attributed to risk factors for the development of DC in other predictors such as dietary habits, bacterial presence, saliva, sociodemographic level, and tooth composition, function, and morphology.[34] In studies evaluating according to HbA1c, DC were found to be significantly higher in groups with poor glycemic control.[21,30] A study conducted in Japan[30] reported a significant difference in DMFT index between diabetic patients with poor control and those with good control. This result was consistent with the findings of the present study. Another study conducted in Greece[21] showed similar DMFT index values in a diabetic group with good glycemic control and a control group. This difference was thought to be due to the sample size and age range of the patients.

DM is known to be an important risk factor for periodontitis, and DM patients with poor glycemic control have an increased risk of periodontitis and alveolar bone loss.[35] To minimize the confounding effect of periodontitis on MT, only patients with at least 15 teeth in the mouth were included in the current study. In addition, the duration of diabetes was at least 1 year and at most 5 years. This was thought to be the reason for the lack of difference between DM patients with poor and good glycemic control. A difference in the number of MT was noted between the DM group with poor control and the healthy control group. Similar to the results of the current study, previous studies reported no difference in caries and a tendency for MT in DM patients.[9] The number of MT provides a direct view of periodontal status and is an important factor in predicting oral health.[36]

Limitations

This study had some limitations, firstly, there was no data on oral hygiene performance such as tooth brushing, flossing, and availability and use of dental care services, all of which have an impact on DMFT. Additionally, the study did not include variables such as oral health habits, fluoride intake, and dietary habits. Root surface caries were also not examined, although T2DM has been significantly associated with root caries.[37]

Although our primary focus was on the DMFT index and serum HbA1c levels, it is clear that several additional biomarkers may play a critical role in oral health. Oral microbial profile, which can be quantified by culture-based methods or 16S rRNA sequencing to detect cariogenic species such as *S. mutans* and *Lactobacillus spp.*, salivary function, including flow rate, buffering capacity, and specific components (e.g., amylase, immunoglobulins),alveolar bone resorption, which can be measured by standardized periapical radiographs or CBCT to measure bone loss, medication information, such as type, dose, and duration of antidiabetic drugs or other drugs that affect salivary flow or bone metabolism, cannot be assessed, which is a limitation of this study.

CONCLUSION

As a result, despite the limitations, the results of this study show a significant relationship between DMFT index and serum HbA1c levels in patients with T2DM. Close collaboration between endocrinologists, dentists, and patients is necessary for better management of oral health, especially in patients with poor glycemic control. Furthermore, increasing awareness of oral health and encouraging DM patients to maintain good oral hygiene and adopt oral health recommendations will contribute to reducing oral complications and improving glycemic control in patients with T2DM.

ETHICAL DECLARATIONS

Ethics Committee Approval

This study was reviewed and approved by the Clinical Researches Ethics Committee of Afyonkarahisar Health Sciences University (Date: 07.07.2023, Decision No. 2011-KAEK-2).

Informed Consent

All patients signed and free and informed consent form.

Referee Evaluation Process

Externally peer-reviewed.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

Financial Disclosure

The authors declared that this study has received no financial support.

Author Contributions

All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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